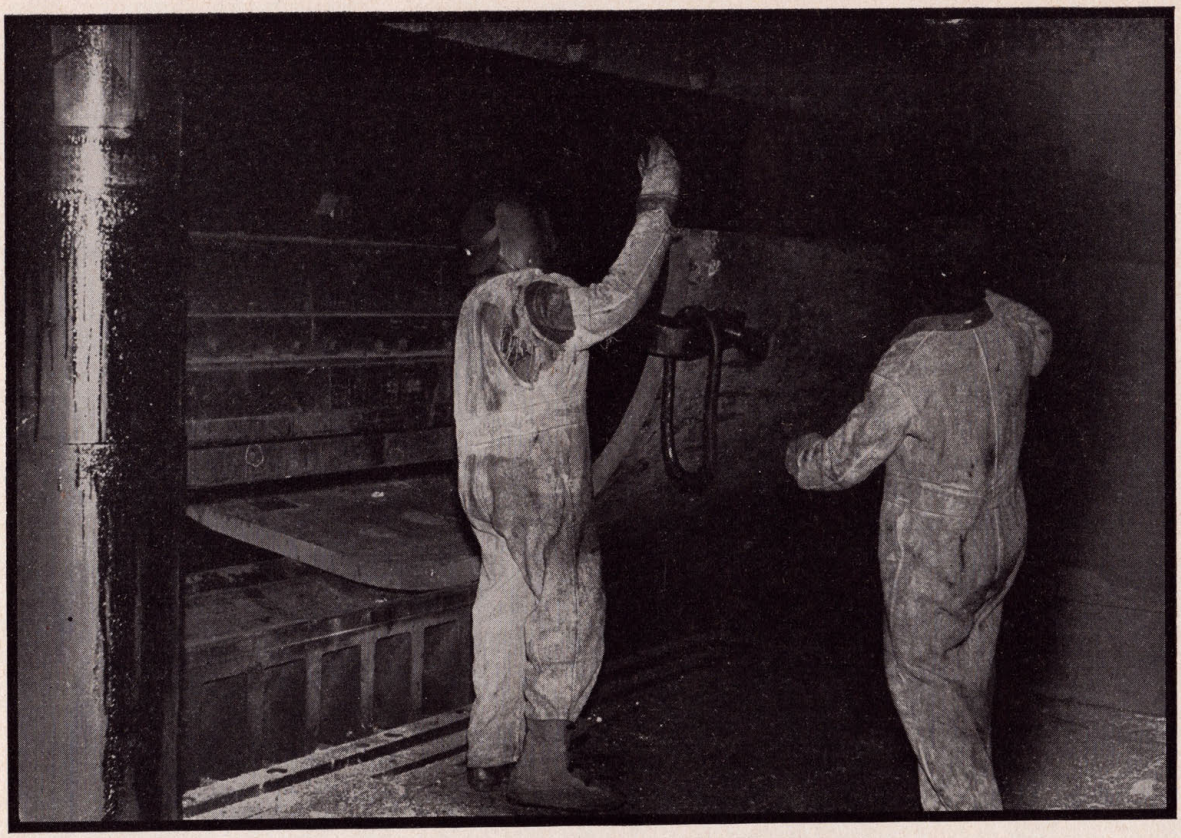
FABRICATION OF BOILER DRUMS

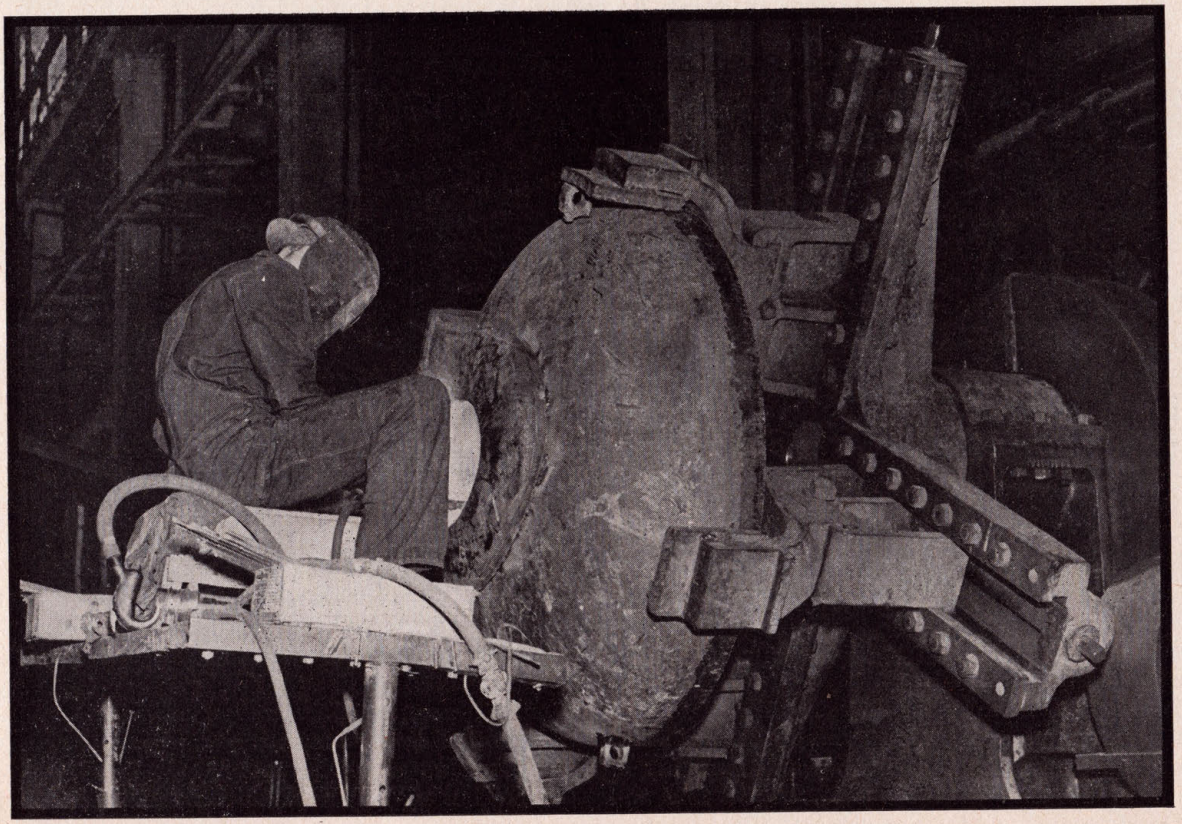
Forming, Welding, Testing and Finishing

COMBUSTION ENGINEERING COMPANY, INC.
200 Madison Avenue, New York 16, N. Y.

This is a reprint of an article originally published in three parts in COMBUSTION, issues of March, April and May 1946. It describes and illustrates modern facilities for the fabrication, inspection and testing of boiler drums, as employed in the main boiler shops of Combustion Engineering Company, Inc., at Chattanooga, Tenn.



Partly formed boiler shell section in 6000-ton press. Pressmen in asbestos suits with man on left signaling to crane operator



Welding reinforcing pad on drum head. Rotation of head is under control of operator so as to weld in most convenient position

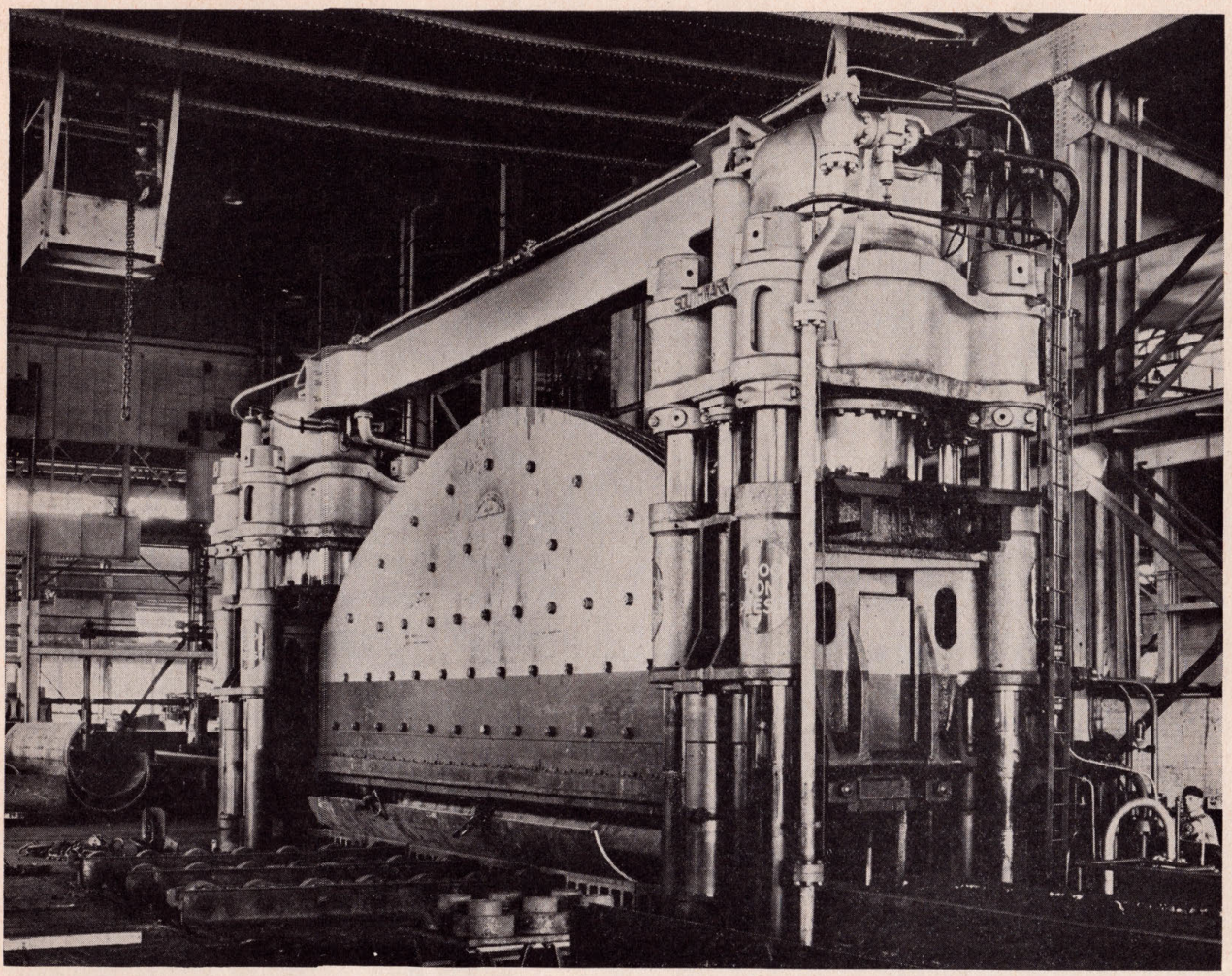


Fig. 1—6000-ton hydraulic press with shell section in dies. Press operator at lower right and crane operator at upper left

FABRICATION OF BOILER DRUMS
Part 1—Forming

This is the first of a series of articles to appear in COMBUSTION describing the fabrication of boiler drums. Subsequent articles will be devoted to welding, testing and finishing.

By H. R. TOWSE
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(*Photographs by Author*)

THE fabrication of boiler drums is a complex, spectacular undertaking involving millions of dollars worth of buildings and equipment for handling, processing and testing as well as the skill and know-how of thousands of men. In addition to the men, materials and property required by the actual manufacture, a modern boiler drum represents the investment of much time and money in research, testing and checking of operation to the end that the safe, dependable and efficient performance of steam-generating units may be assured. The advances made in metallurgy and welding technique have probably been the outstanding factors in the fabrication of boiler drums as we know them today.

In this article will be described the normal sequence of operations in the forming of boiler plate in the Chattanooga plant of Combustion Engineering Company, Inc. During the course of more than half a century, in which boiler building has advanced from a more or less crude procedure to a highly specialized industry requiring great accuracy of manufacture, this plant has been a leader in developing means and methods to keep pace with the ever-increasing requirements of pressure and

temperature in stationary and marine steam-generating practice.

The first boiler drum to be fabricated by fusion welding and stamped with the Boiler Code Symbol of The American Society of Mechanical Engineers was built in these shops. In the intervening years, thousands of welded boiler drums and pressure vessels of all types and sizes have been fabricated here. These include shell plate up to $5^1/_4$ in. thick and boiler drums weighing over 80 tons.

Upon the delivery of the boiler plate from the rolling mill, it is inspected for surface flaws during the unloading by experienced shop men who also check the size and thickness. The mill test reports of physical and metallurgical properties are accepted unless the shop inspector has reason to doubt a particular piece. In such cases, samples are tested in the shop laboratory before acceptance.

All plate used in the manufacture of boiler drums must conform to the specifications of the Code for Power Boilers of The American Society of Mechanical Engineers. In this article, the plate used in a boiler drum will be considered under the classifications of shell plate, head plate and plate for reinforcing pads. The formation of plate used in drum heads is carried on in one part of the shop while the shell plates are formed in another area.

The heavier plates are formed in a press. Before forming, the ends are trimmed in a milling planer and the edges are ground to a small radius so as to minimize the danger of cracking when they are bent. The side edges of the plates are not machined until after the forming operation. If a plate is from $1^1/_2$ to 2 in. thick, it is stress-relieved in a furnace and then allowed to cool slowly to room temperature, after which it is ready for cold-forming to final curvature in a hydraulic press. If it is over 2 in. thick, the Boiler Code requires it to be normalized before it is formed. Normalizing the plate consists of placing it in a furnace and heating to 1600 to 1750 F, depending on the composition of the steel, and holding the temperature for $^3/_4$ of an hour per inch of thickness. Upon completion of the normalizing operation, the plate is removed from the car-type furnace and

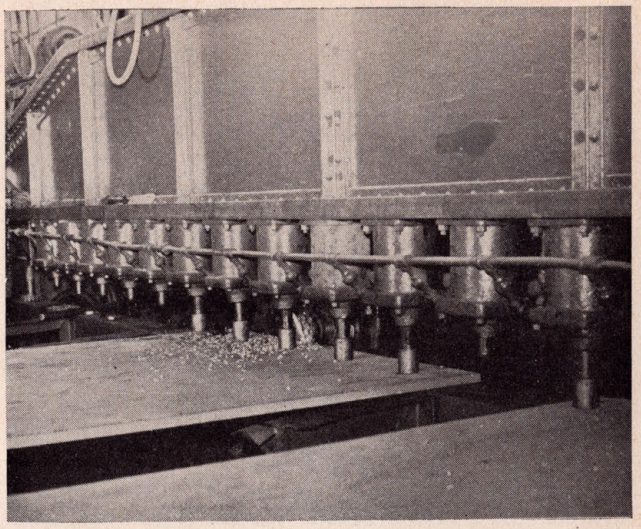

Fig. 3—Trimming ends of shell plate in milling planer. Plate is held in position by hydraulic clamps

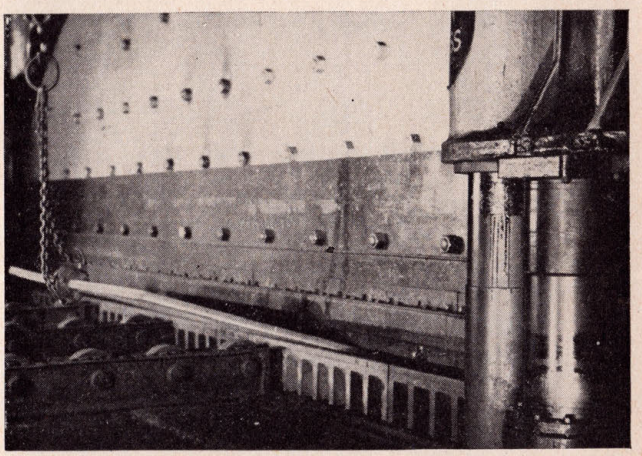

Fig. 4—Start of forming operation. Edge is crimped in dies and then the plate is moved through the press to crimp the other edge

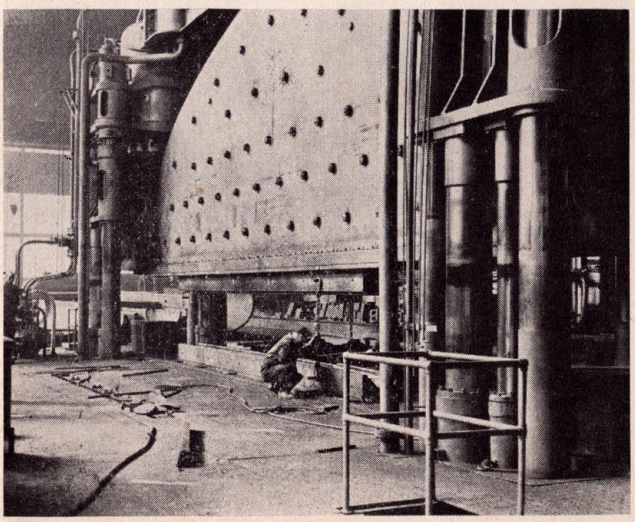

Fig. 2—Press operator checking dies of 6000-ton press. Controls are at far end of press at extreme left

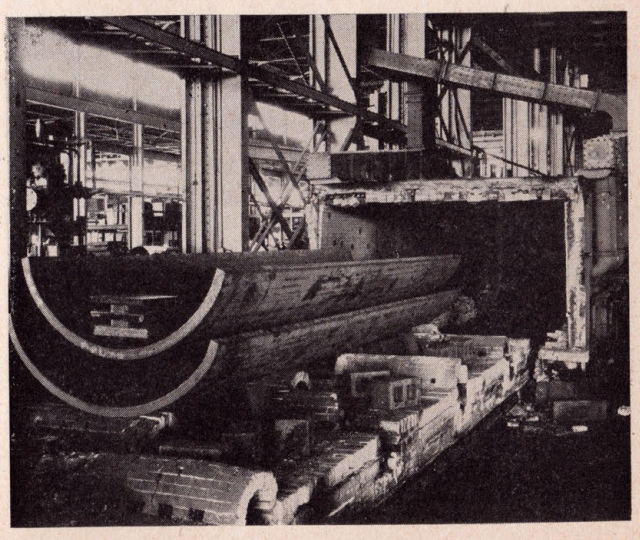

Fig. 5—Formed shell sections after stress-relieving in heat-treating furnace. Test plates shown in upper shell will go to the laboratory

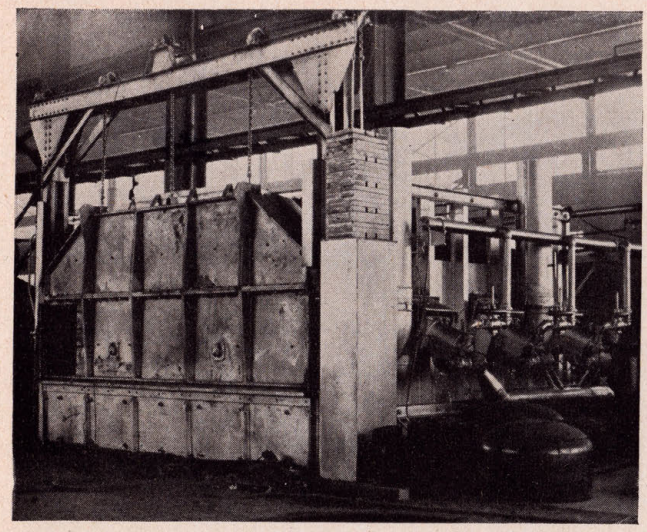

Fig. 6—Furnace in which head plates are heated

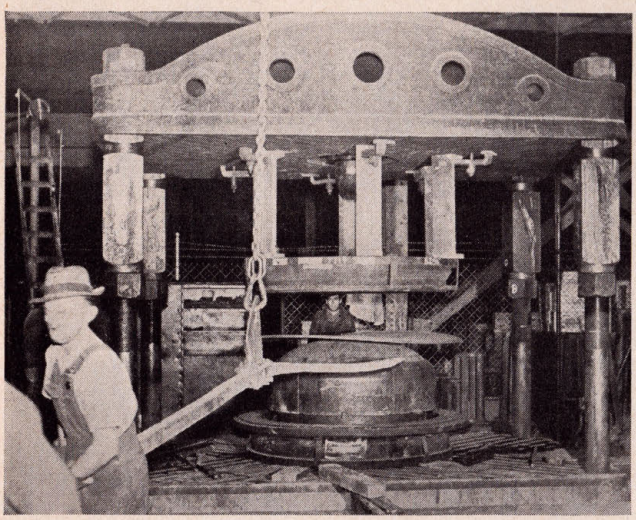

Fig. 7—Circular head plate is removed from furnace and placed on die of hydraulic head press

is picked up by the crane and carried to the press, where advantage is taken of the normalizing heat for hot-forming.

The crane is unusual, being a double, adjustable arrangement with a capacity of 30 tons. Each half, consisting of two beams, carries a hook and may be separated from the other half—so as to accommodate various lengths of plates. One operator controls both sections which may be moved separately or in unison and his cab may be moved to any point along the rear half of the crane so as to be directly above the work.

Pressmen in asbestos suits and helmet shields maneuver the hot plate into position, aided by the crane operator. The procedure is superintended by the press foreman who directs the handling of the plate and the operation of the press by unmistakable hand signals. In addition to the foreman, the press crew consists of the crane operator, a press operator and six pressmen.

Plate Forming

When the hot plate reaches the press, one edge is crimped. Then the plate is moved through the press and after removal of scale by a blast of compressed air, the other edge is crimped. Forming proceeds from the edges toward the center. The crane aids in shifting the plate which is also moved by manipulating rams which have a vertical and sidewise movement through the lower die. After each downward stroke of the press beam, the curvature is checked with a templet. Downward travel is limited by shims under each end of the beam. Hot-forming is stopped before the final curvature is reached and the shell section is returned to the furnace for stress-relieving, after which it is allowed to cool slowly to room temperature before final cold-forming.

All final forming of shell sections is done cold. If, during cold-forming, the limit of the allowable elongation of the outside fibers is approached, the shell section is subjected to intermediate stress-relief and cooling to room temperature before further cold-forming. Elongation is a function of plate thickness and radius of curvature and the procedure may be varied to suit the conditions. In addition to allowing accurate measurement of

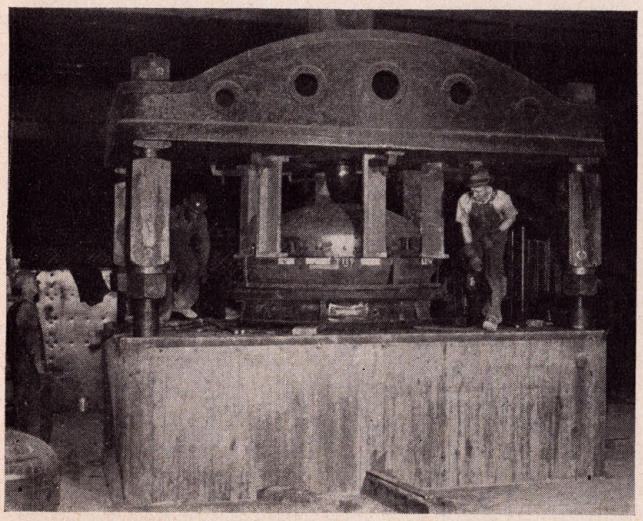

Fig. 8—Lower die forces plate through the upper ring die to form the head. The die at the top of the press forms flanged-in manholes

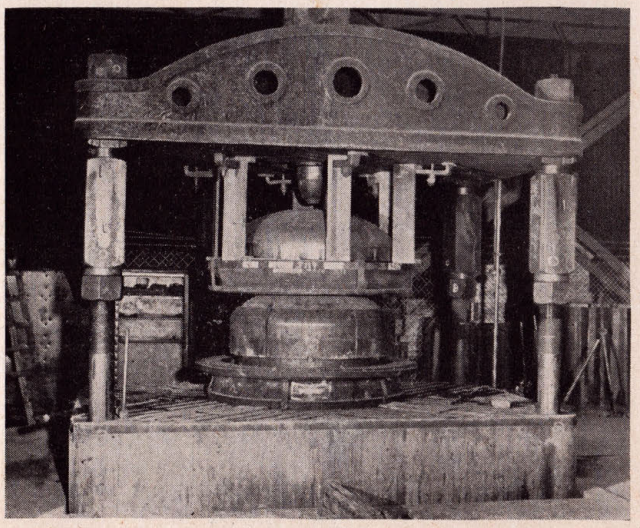

Fig. 9—Lower die receding from formed head

the finished work, final cold-forming provides an excellent test of the steel.

The press used in these forming operations was designed by C-E engineers and is the largest and most powerful of its type so far built and has formed the heaviest and thickest boiler plate in use today. The maximum thickness capable of being formed in this press is not known but it is believed to be considerably greater than any requirements of modern pressure vessels. Some idea of the speed of this press may be gained from the fact that in 40 minutes from the time a plate 25 ft × 10 ft × $3^1/_{16}$ in. thick was removed from the normalizing furnace, the plate was ready for stress-relief and final cold-forming and a second plate of the same size was on its way to the press. The actual hot-forming operation took about twenty minutes.

The power for accomplishing this task is derived from two large hydraulic cylinders connected by a built-up top beam weighing about 250 tons. There is a similar bottom beam beneath the floor. The top beam has sliding shoes to equalize the movement and to prevent binding. A crossover pipe equalizes the pressure between the two main cylinders. The force applied by the beam is 1500 tons per cylinder without the use of an intensifier which increases the force to 3000 tons per cylinder or 6000 tons total. The overall height is 49 ft with 27 ft above the operating floor. The clearance between end posts is over 40 ft. The weight of the entire unit is slightly over 2,000,000 lb.

Plate Rolling

Light plates are trimmed for welding on all four edges in a specially designed planer, after which the longitudinal edges are crimped in a 600-ton press or in dies in the bending rolls which are used to cold-roll the plate to final cylindrical form. Rolled shells may be made from one plate if the entire shell is of one thickness, or from two plates if the boiler tube hole section is thicker than the opposite section. Rolling, clockwise and counter-clockwise, continues until the shell section is true to templet. Since no stress-relief is required at this stage, the sections pass on to the fit-up and welding operations.

While the shell sections are being formed, operations on the boiler drum heads are going on in another part of the shop where, after inspection and layout, the procedure followed on the circular head plates depends on whether they have flanged-in manholes or reinforced manholes. The latter are heated to normalizing temperature in a special furnace and treated in the same man-

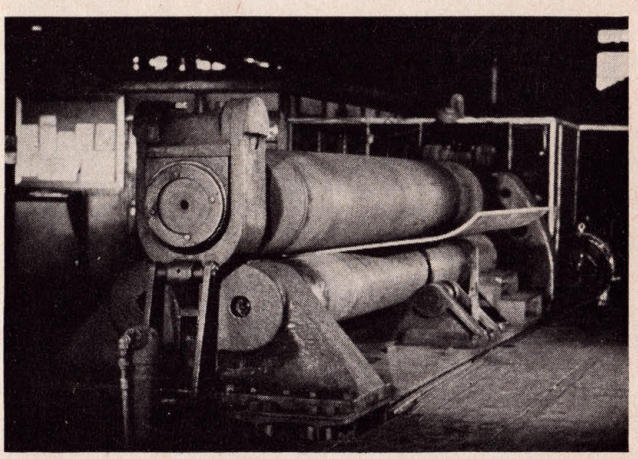

Fig. 11—Plate being cold-rolled after crimping longitudinal edges in dies

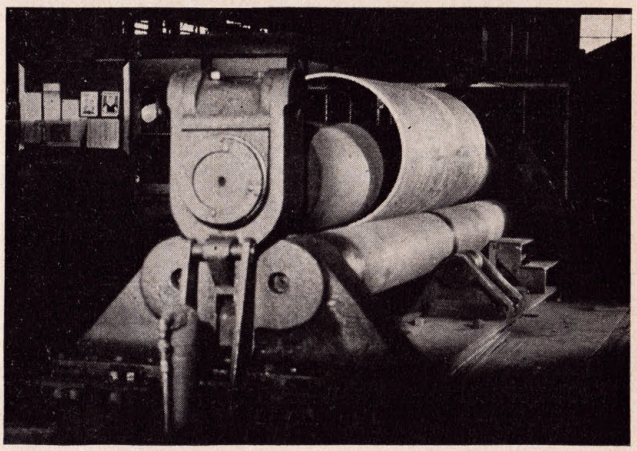

Fig. 12—Complete shells or sections of shells are rolled back and forth until they are cylindrical

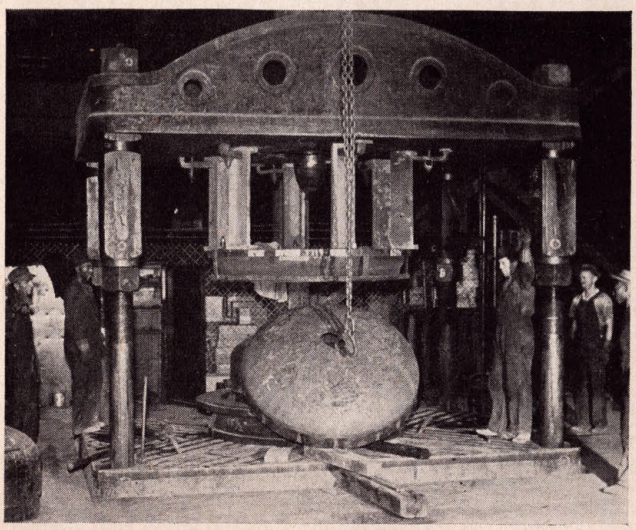

Fig. 10—Drum head is removed by crane

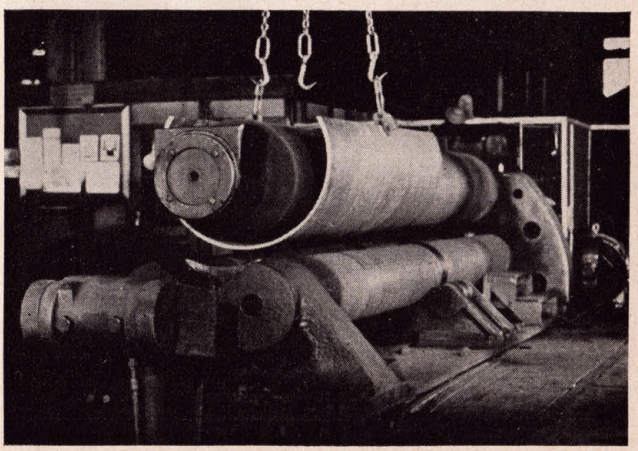

Fig. 13—Shell section being removed by a crane

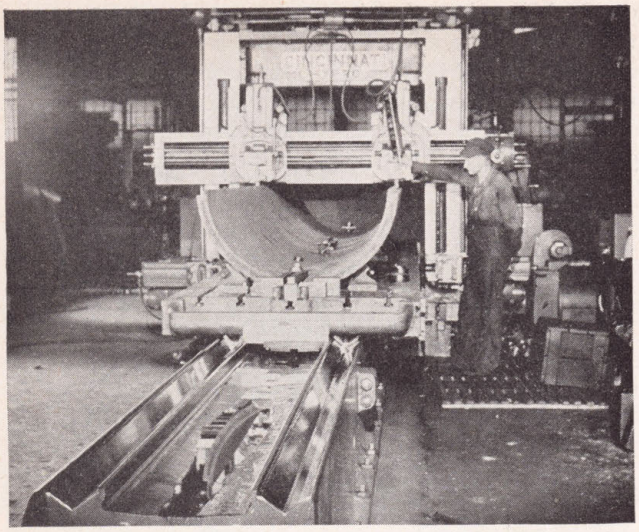

Fig. 14—Longitudinal edges are trimmed and machined in a planer for welding. Both edges are machined at the same time. Forming is so accurate that two or three shell sections may be set up in tandem and machined

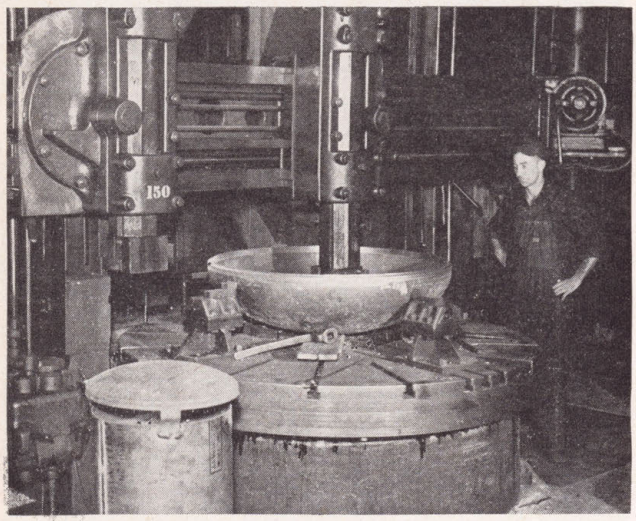

Fig. 15—Vertical boring mill machining manhole flange of drum head

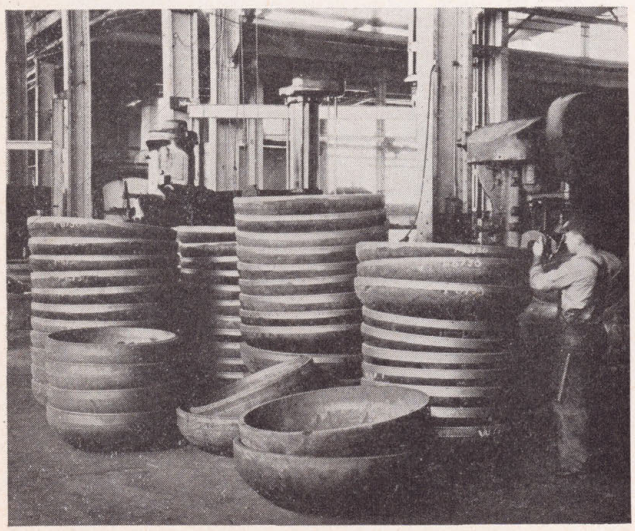

Fig. 16—Drum heads with flanged-in manholes being gaged after machining for welding

ner as the shell plates. When they are ready, they are removed, one at a time, by a group of men who guide a counterbalanced fork, on a crane hook, under a plate and take it to the head press where it is centered on a die and forced upward through a ring die to form the head to a true semi-elliptical shape. After cooling to room temperature, the manhole is flame-cut and prepared for welding the reinforcing plate in place. These plates are flame-cut and hot-formed after which manholes are flame-cut. After welding, the head is stress-relieved and is then ready for machining.

For heads with flanged-in manholes, the manhole opening is marked, flame-cut and ground and then the head and manhole are hot-formed. A die at the top of the press forms the elliptical manhole as the head is formed. After cooling, the manhole flange is trimmed with the flame cutter and if required, the manhole is cold-sized in a gooseneck type press. If there is insufficient surface for a gasket seat, a band is shrunk on the manhole flange and welded. From this point, the procedure on the two types of heads is the same. Manhole gasket seats and head flanges are machined in a vertical boring mill. Manhole openings of reinforced heads are machined in a specially designed eccentric mill. After completion of the machining operations on the head, nozzle openings are marked, drilled or flame-cut and nozzles are fitted, using a face plate, and welded before the head is welded to the shell.

Preparation for Welding

Upon the completion of the cold-forming operation on the shell, it is clamped on a large planer where the longitudinal edges are squared and machined for welding. The forming operation is so accurate that two or three sections of the same curvature and thickness can be set up in tandem and machined at the same time. When a shell has sections of unequal thickness, the outside and inside edges of the thicker section are tapered to meet the edges of the thinner section so that the neutral lines of the two sections coincide.

When the machining operations on the heads and shell sections have been completed, the various components are ready to be fusion-welded to form the drum.

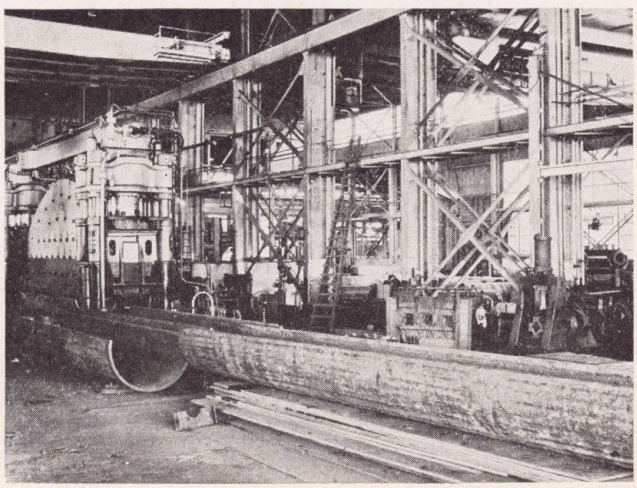

Fig. 17—View showing formed shell sections and 6000-ton press and crane in the background

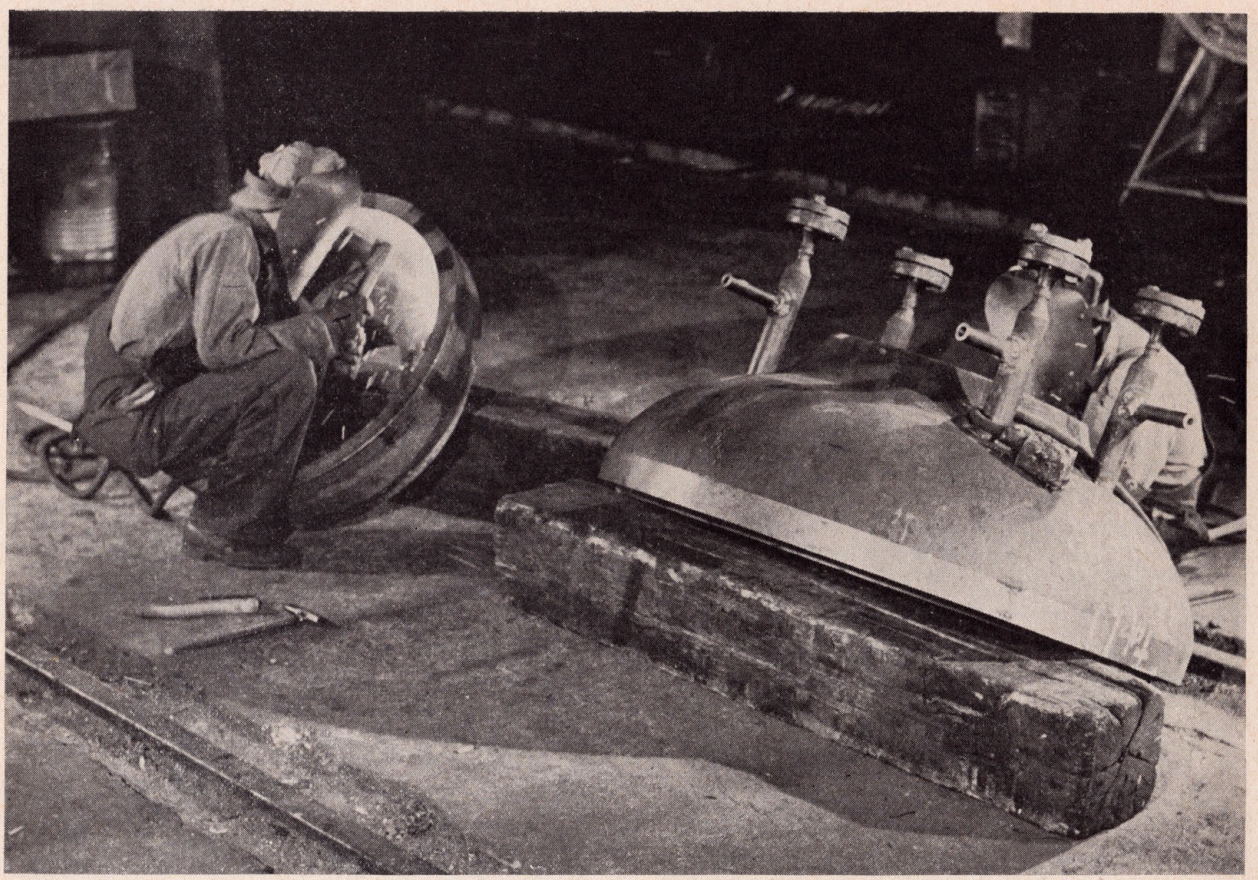

Fig. 1—Welding attachments to high-pressure drum heads

FABRICATION OF BOILER DRUMS
Part 2—Welding

This article describes the normal procedure in the metallic-arc method of fusion welding used in the fabrication of boiler drums at the Chattanooga plant of Combustion Engineering Company, Inc. Subsequently, the testing and finishing operations will be described.

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Photographs by Author

IN THE fusion-welding process, the work forms one electrode and the weld rod, held in a clamp, either by the operator or by the automatic welding machine head, forms the other electrode. When the arc is struck, the heating effect of the current causes the weld rod metal to flow into the weld groove and fuse with the base metal. The work may be positive (straight polarity) or negative (reverse polarity) depending on the type of rod and the kind of work.

The type of weld rod has a most important relation to this phase of drum fabrication. The shop facilities include a specially designed rod-coating machine and baking oven in which various types of rods may be given different kinds of coatings, depending on the work on which they will be used. This machine also provides the opportunity for immediate weld rod research whenever special problems arise.

Briefly, the purposes and functions of coated weld rods may be stated as follows:

To provide weld metal characteristics equal to those of the base metal and to control the physical and chemical characteristics of the weld bead through the introduction of the required elements in the coating.

To prevent the formation of oxides and nitrides by shielding the arc with an inert gaseous envelope.

To provide a slag covering for the molten weld metal to prevent it from being oxidized and to retard the cooling rate.

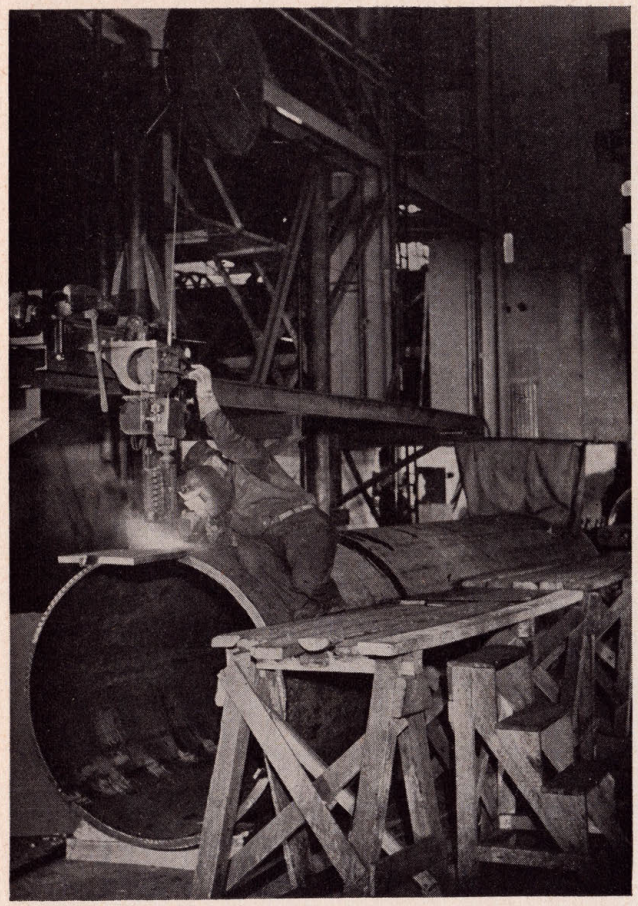

Fig. 2—Automatic welding of longitudinal seam. Test plate is shown at end of shell

Fig. 3—Hand welding on boiler shell

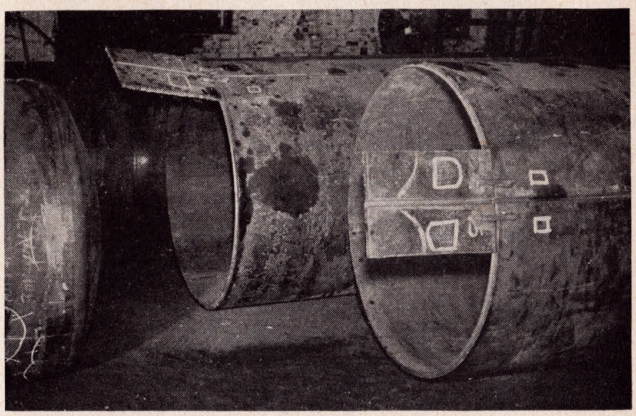

Fig. 4—Plates tack-welded to shell will form test plates after longitudinal weld is completed

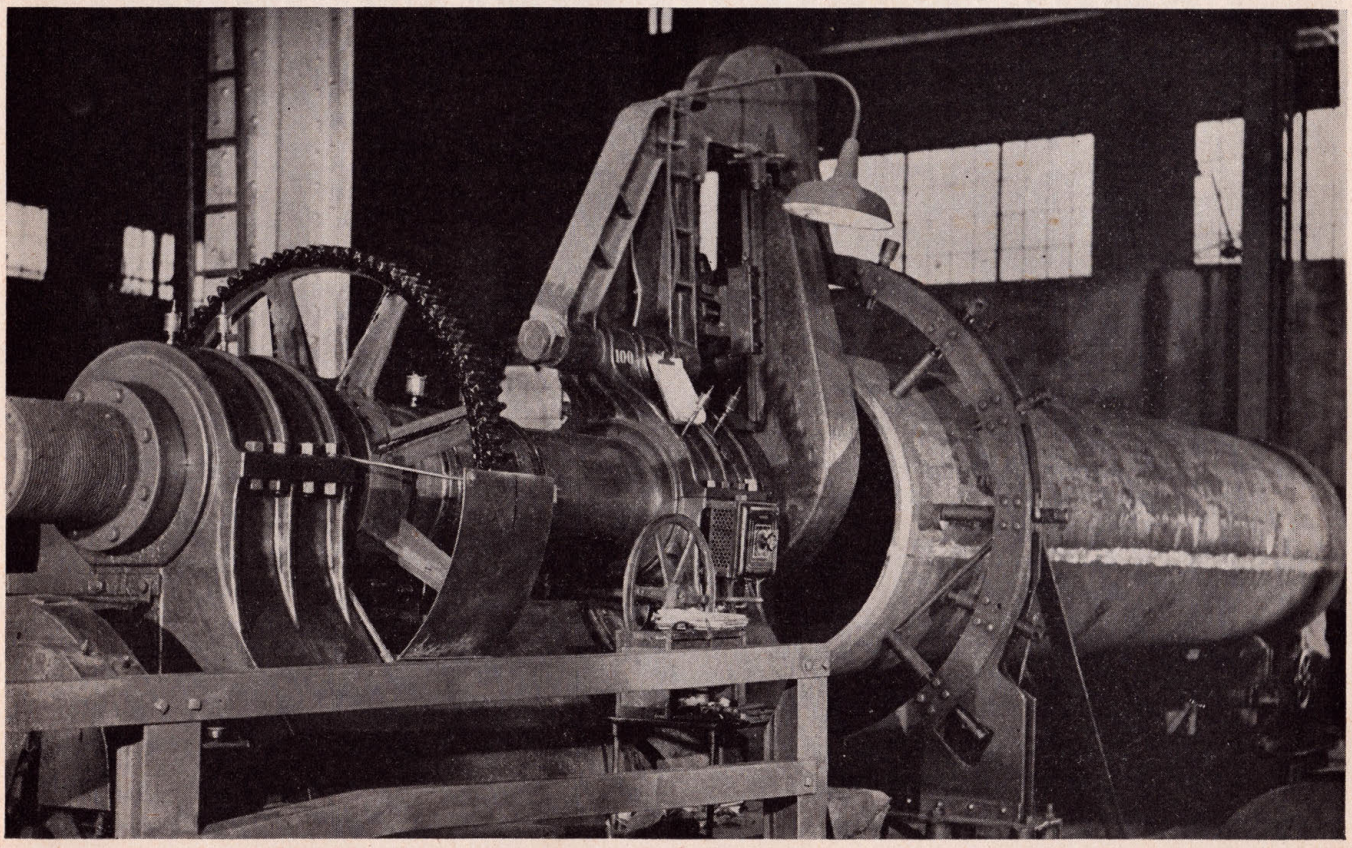

Fig. 5—Ends of shell are machined preparatory to welding on the drum heads

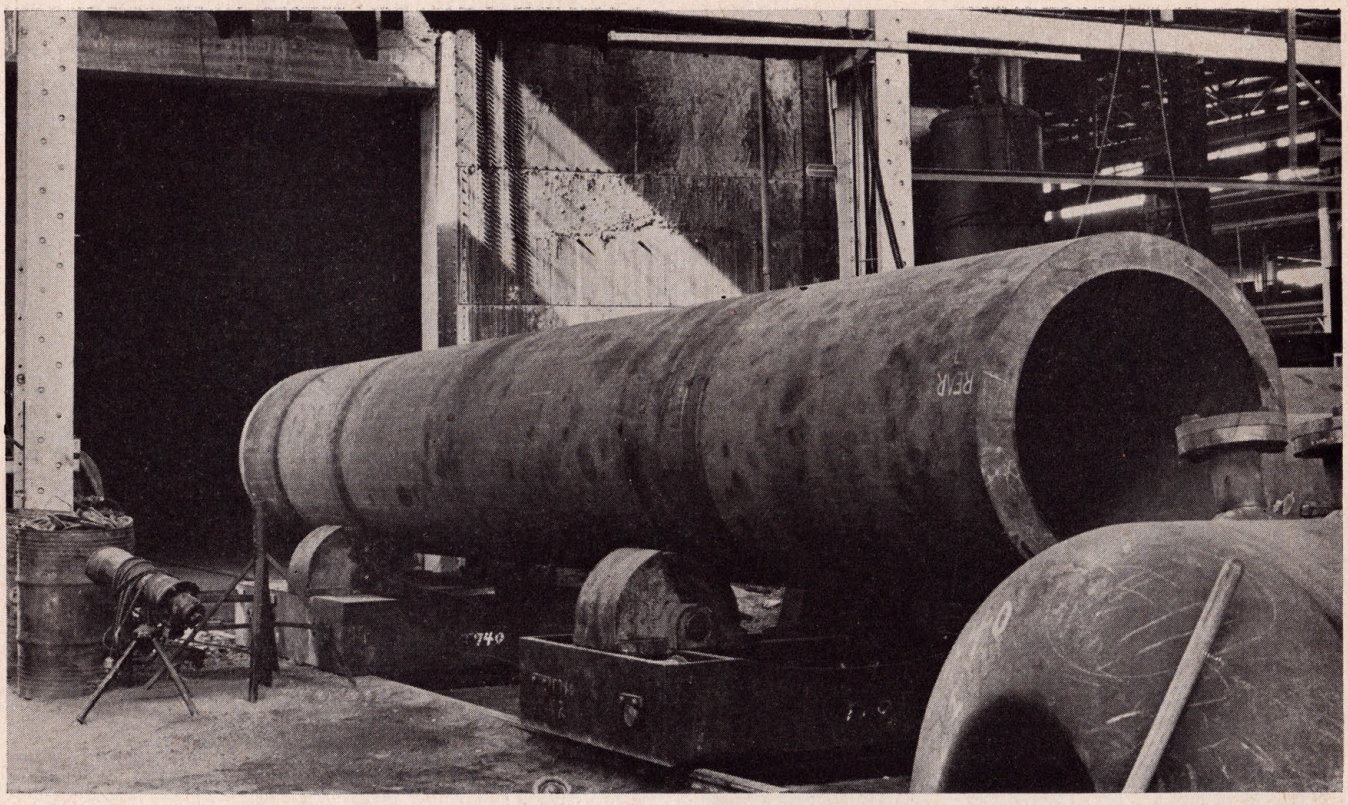

Fig. 6—Welded shell ready to enter million-volt X-ray room

To make it easier to strike and maintain steadiness of the arc.

To obtain greater speed in welding through better arc control and lower thermal losses.

To provide for interchangeable polarity for control of penetration.

The welding operations described herein are the result of the processes, techniques and designs for uniform stressing developed since 1930 in the Chattanooga shops of Combustion Engineering Company. In laboratory tests and in tests with full-sized drums, the welded joints have been proved to have characteristics equal to, or better than, the boiler plate. Furthermore, since the beginning of welding practice in drum fabrication, there have been no failures in the actual operation of thousands of welded boiler drums built by Combustion Engineering for both stationary and marine boilers.

In the first article of this series on the sequence of operations in the fabrication of boiler drums,* the forming and machining of shells and heads were described. After the machining operations on the longitudinal edges of the shell sections are completed, the sections are fitted together and tack-welded on the inside. Then two plates from the same lot of material and of the same specifications and thickness as the shell plate, are tack-welded to one end of one joint of the shell so that the edges to be welded are a continuation and duplication of the longitudinal edges of the shell. The weld grooves are then filled by successive thin layers of weld beads, either by automatic or hand welding, the metal being deposited in the test plate groove continuously and in the same manner as in the longitudinal groove of the shell. At the opposite end of the groove to the one hav-

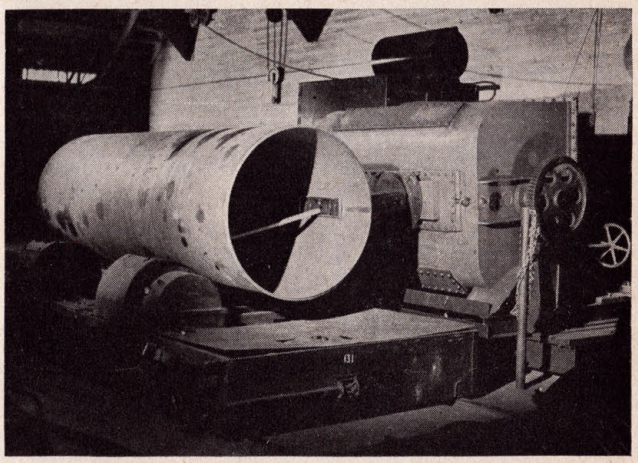

Fig. 7—Stationary type 400,000-volt X-ray machine. Shell on car moves along a track at side of machine

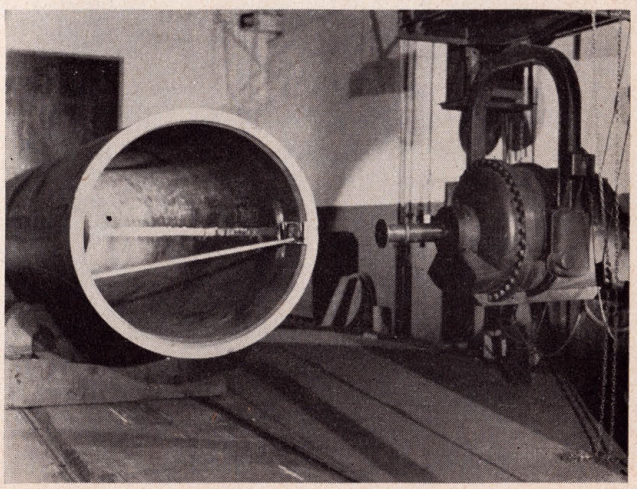

Fig. 8—Million-volt X-ray machine in position to photograph longitudinal seam

* See COMBUSTION, March, 1946, p. 38.

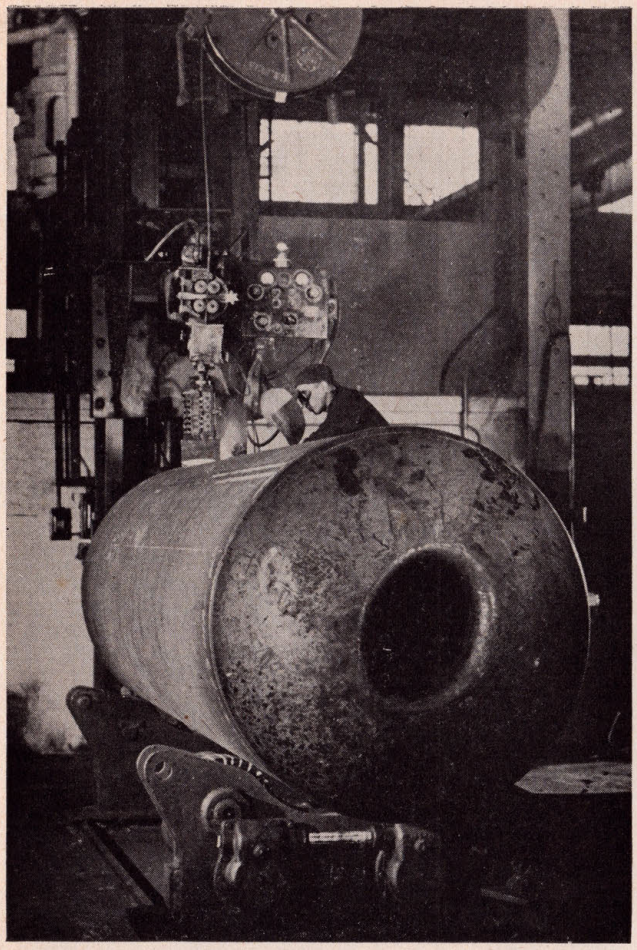

Fig. 9—Automatic welding of circumferential seam. Drum is rotated under the stationary welding head

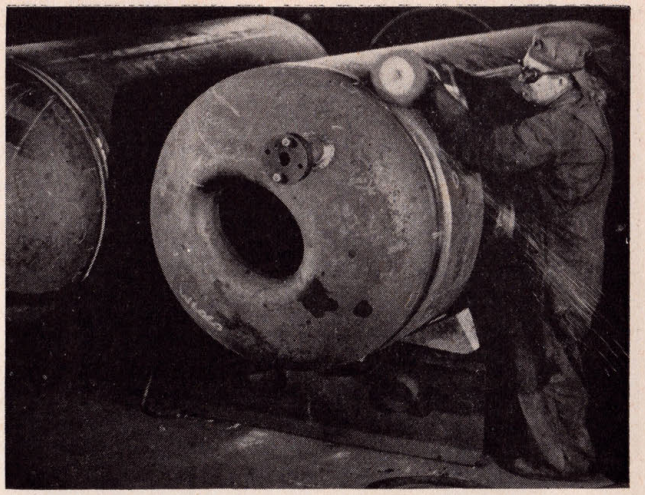

Fig. 10—Grinding circumferential seam of drum

ing the test plate, and on both ends of grooves where no test plate is attached, two small bars forming a "V" are tack-welded to the shell so as to continue the weld properly to the end.

Each new layer of weld metal serves to normalize the grain structure of the previous layer. After each layer is deposited, the welded surface is cleaned with a rattler—a blunt-nosed tool operated by an air hammer—to remove slag and to allow inspection for defects. The laying-in of weld metal is continued above the surface of the shell and then the last layer is ground off flush with the surface, thereby removing any unrefined metal as well as providing a smooth surface for radiographic examination. The weld is then chipped out to sound metal on the inside of the shell and the groove thus formed is rewelded by hand. This weld is continued

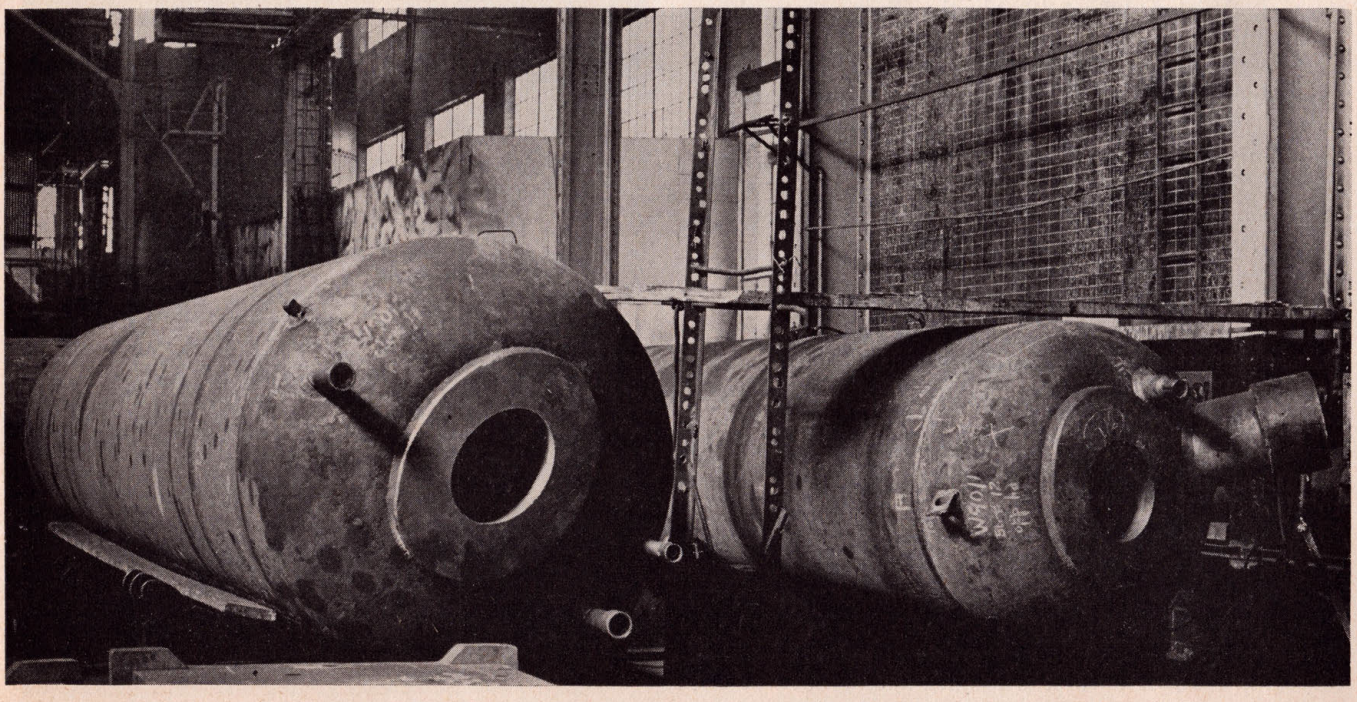

Fig. 11—Welded drums with reinforced manholes ready for stress-relief

above the inside surface and ground off flush as was done on the outside. The test plate is cut off and sent to the testing laboratory.

The shell is now ready for radiographic examination of the longitudinal seams. Three different types of machines are available for this work. The machine which is used depends on the thickness and length of the shell. Portable machines, mounted on four-wheel trucks and operating at 250,000 volts are used for smaller work. Heavier shells and drums are X-rayed by stationary 400,000-volt machines mounted at the side of tracks along which the drum can be moved on a car. Examination of very thick or long shells and drums is made with the 1,000,000-volt machine which is supported by an overhead pantograph with a universal crane mount so that the tube can be used in any position. This unit is housed in a special room with thick concrete walls. No persons are allowed in the room while X-raying is in progress. Power cannot be turned on until all doors of the room are closed. If any defects are disclosed by the X-ray photographs, the parts in question are chipped out, re-welded and given another examination.

Upon approval of the X-ray photographs, the shell is placed either in a lathe or in a horizontal boring mill where the ends are trued up and machined for welding on the heads. In the meantime, the heads have had the necessary attachments such as reinforcing pads, nozzles, etc., welded in place as the work can be handled more conveniently and welding can be in down-hand position.

After fitting and welding internal connections, the heads are fitted and tack-welded to the shell. The circumferential welds are made in the same manner and with the same type of groove as the longitudinal welds except that for the former the drum is rotated under a stationary electrode while for the latter the shell remains stationary and the arc moves along the seam. No test plates are required for the circumferential welds when the conditions of welding are the same as for the longitudinal welds.

Examination of the circumferential seams follows the same procedure as for the longitudinal seams, except that the drum is revolved in front of the X-ray tube.

Upon approval of the X-ray photographs, the drum is ready to have nozzle openings drilled or flame-cut. Nozzles and externals such as superheater supports, etc., are then welded and the drum is cleaned preparatory to stress-relieving.

The car-type furnaces used for relief of locked-up stresses caused by the welding operations are fired by oil and have automatic recording instruments for the control of temperature. The drums are loaded on drum chairs on the furnace car which is then rolled into the furnace. The end door is closed and the drums are heated to 1150 to 1200 F and held at that temperature for one hour minimum per inch of thickness. When this so-called "soaking" is completed, the drums are allowed to cool slowly in the furnace after which they are prepared for the hydrostatic test.

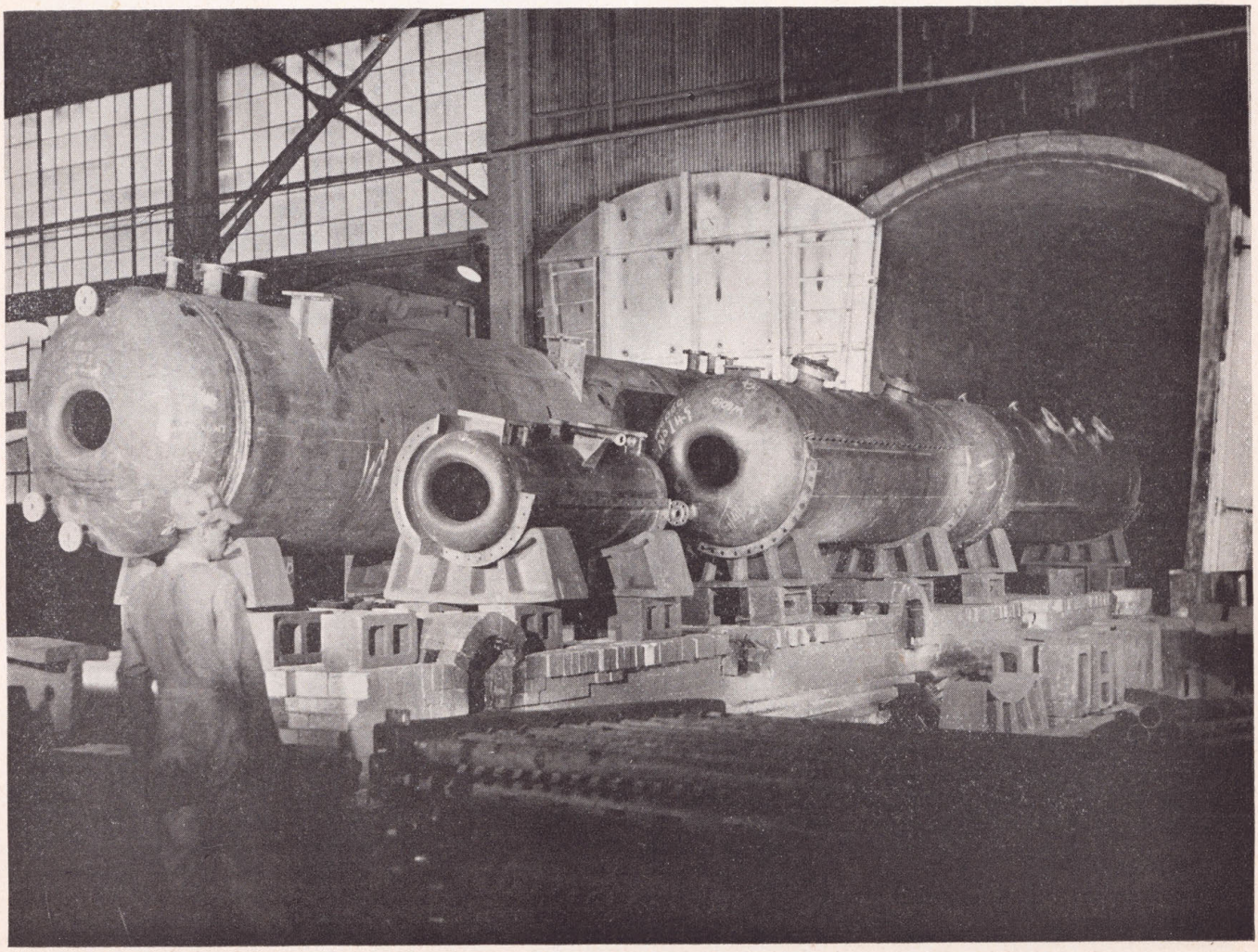

Fig. 12—Welded drums entering car-type furnace for stress-relieving

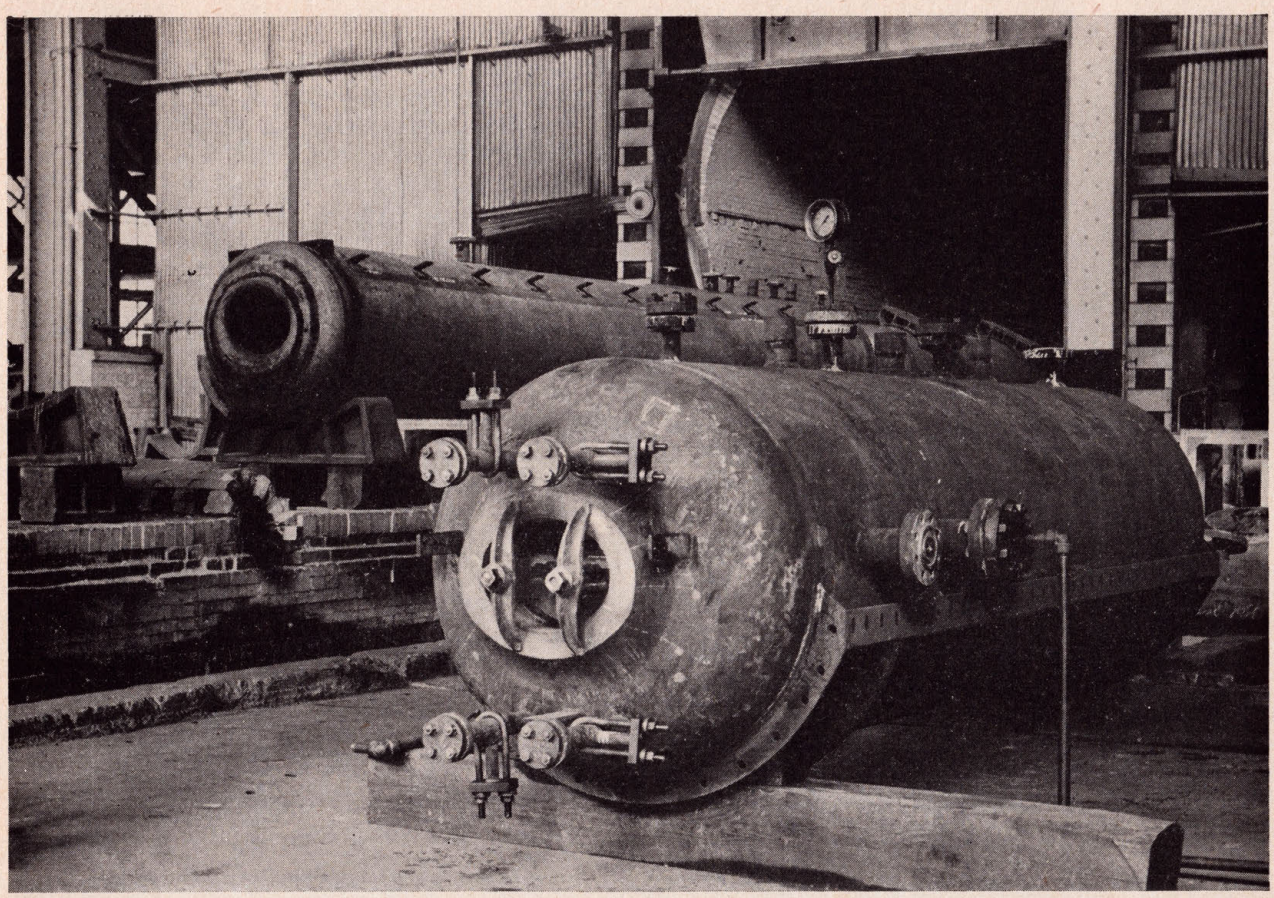

Fig. 1.—Hydrostatic test set-up for highest pressure marine boiler drum ever built. Two flanges remain to be blanked. Pressure gage and test pressure pipe are connected. Drum is designed for 1535 psi. Drum on car in background is ready to enter furnace for stress relief.

FABRICATION OF BOILER DRUMS
Part 3—Testing and Finishing

This article describes the normal testing and finishing procedure used in connection with the fabrication of boiler drums at the Chattanooga plant of Combustion Engineering Company, Inc. Previous articles of the series appeared in the March and April issues.

By H. R. TOWSE
Combustion Engineering Company, Inc.

Photographs by author and by Metallurgical Department

THROUGHOUT the process of fabrication of a boiler drum, the parts which will be subjected to stress are under scrutiny of one kind or another. Four methods of checking are used, based on the procedure approved by the Power Boiler Code of the American Society of Mechanical Engineers.

Inspection

1. Inspection starts with the delivery of the plate from the rolling mills and continues at every stage of fabrication thereafter until the finished product leaves the plant. This is done by experienced shop men and by an insurance company inspector qualified for inspecting boilers for the particular state or municipality in which the boiler is to be installed. In addition to the visual inspection of the plate itself, each machine operation is checked by the foreman in charge. Under special conditions or circumstances, other methods of examination, which are not in the normal procedure, are available for use on specification, such as complete examination by chemical analysis, heat treating and micro-photography. Also for examination of plate edges prior to welding and

other parts which are not X-rayed, a Magnaflux machine and Supersonic Reflectoscope may be used.

Physical Testing

2. Physical testing is conducted on test samples of thicker plate at the completion of the forming operation and on specimens of the welded test plates at the completion of the longitudinal seam weld. The bend-test specimen of the welded joint is required to be transverse to the welded joint of the full thickness of the plate and of rectangular cross-section with the width $1^1/_2$ times the thickness of the specimen. The inside and outside surfaces of the weld are required to be machined to a plane surface flush with the plate, with the edges of this specimen rounded to a radius not over 10 per cent of the thickness of the plate. The specimen is bent cold under free bending conditions until the least elongation, measured within or across approximately the entire weld on the outside fibers of the bend-test specimen, is 30 per cent.

When a crack is observed in the convex surface of the specimen between the edges, the specimen is considered to have failed and the test is stopped.

One tension test is required of the welded joint and one of the weld metal. The joint specimen is cut so that the direction of the weld is across the specimen which is required to be the full thickness of the welded plate after the inner and outer surfaces have been machined flush with the plate. The tensile strength of the welded joint is required to be not less than the minimum of the specified tensile strength range of the plate.

The tension-test specimen of the weld metal is required to be taken entirely from the deposited weld metal and its tensile strength must be at least that of the minimum range of the plate which is welded and its elongation in 2 in. must be at least 20 per cent.

If necessary, on account of limitations in the capacity of the testing machine, the Code allows the bend and transverse tension specimens to be cut with a thin saw into as many portions of the thickness as necessary, each of which shall meet the requirements.

Radiographic Examination

3. Radiographic examination of welds furnishes a very valuable method for non-destructive testing of metal within the limitations of its applications. The method is applied to welds to ascertain the soundness of both the weld and the adjacent metal. It shows defects such as gas cavities, slag inclusions, unsatisfactory penetration, imperfect fusion and cracks. Equal spaces are marked

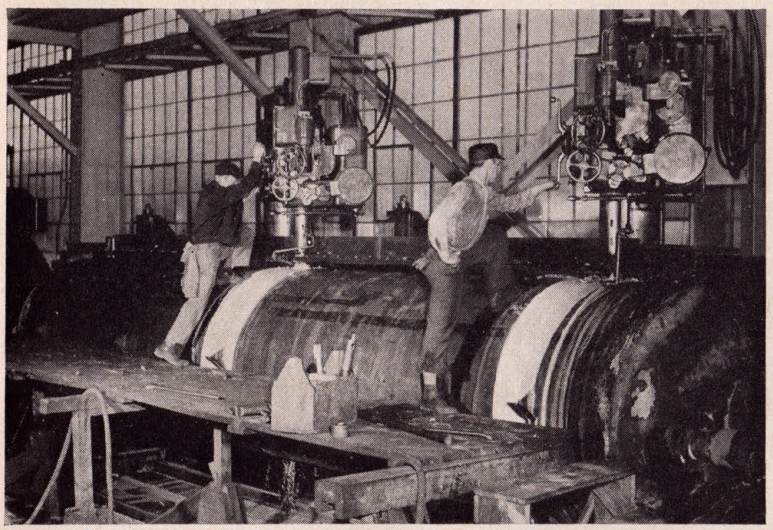

Fig. 3 (below).—Close-up of tube-hole drilling operation; showing jig which is used to assure accuracy of alignment

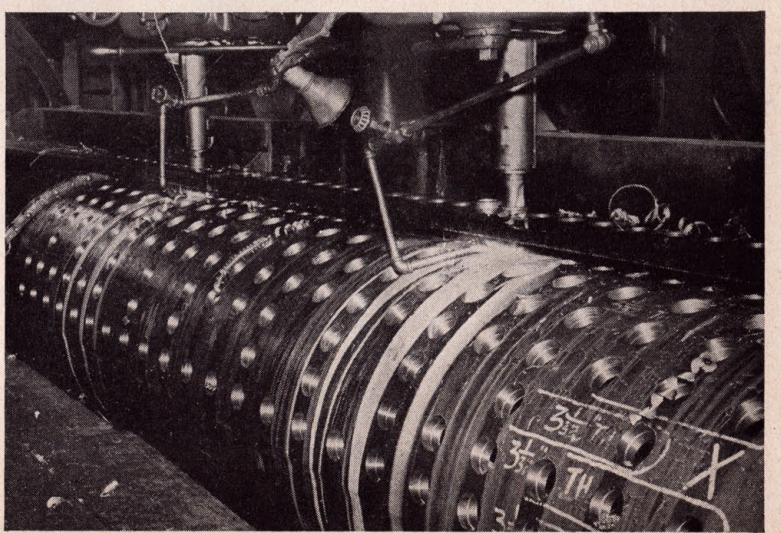

Fig. 2 (above).—Radial drill presses are used for drilling and reaming tube holes. Drilling jig is in position

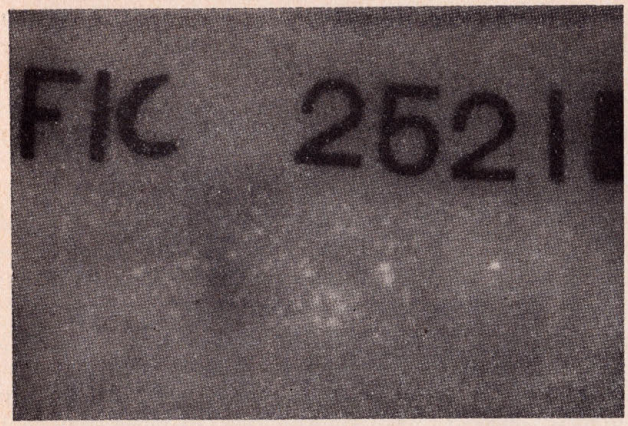

Fig. 4.—Radiograph showing porosity

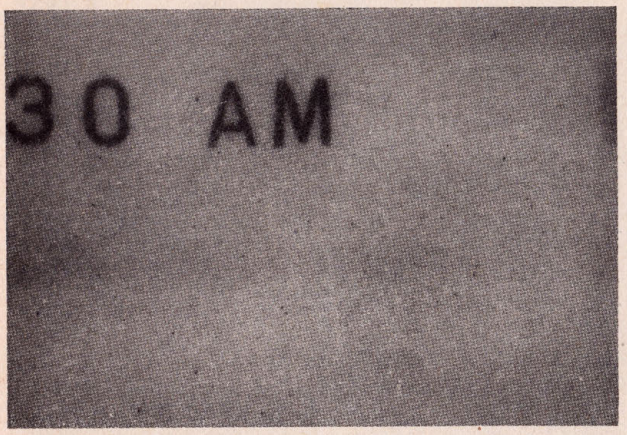

Fig. 5.—Radiograph of acceptable weld

Fig. 6.—Radiograph showing slag inclusions

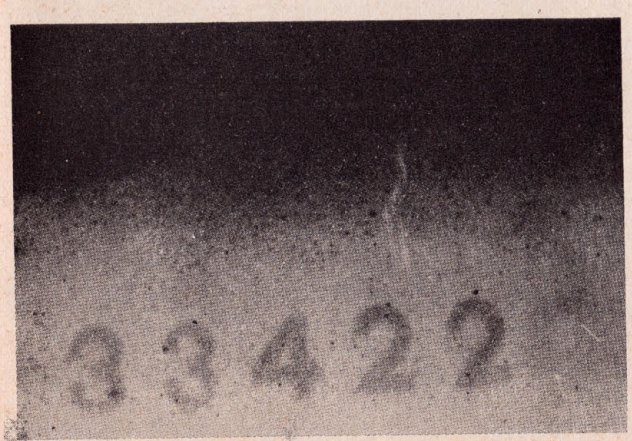

Fig. 7.—Radiograph showing crosswise crack
(made without Buckey grid)

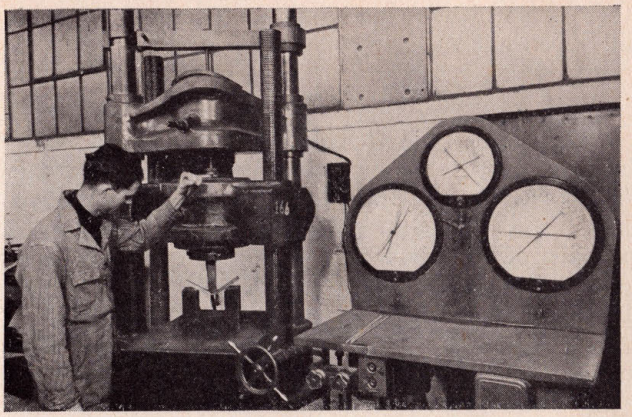

Fig. 8.—Start of bend test

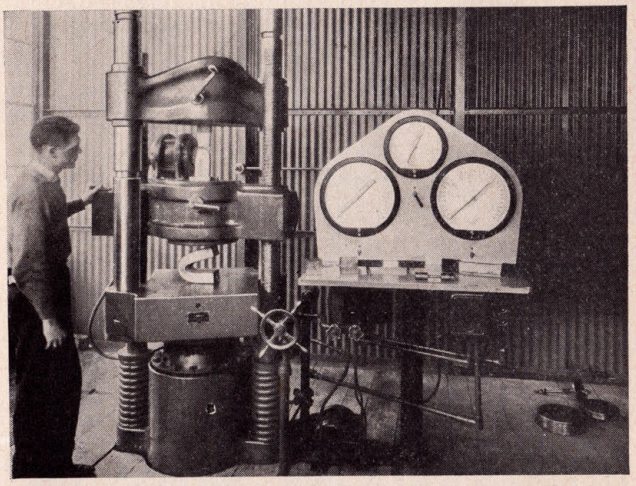

Fig. 9.—Tension test has been completed on specimen in upper part of machine; bend test is being made in lower part

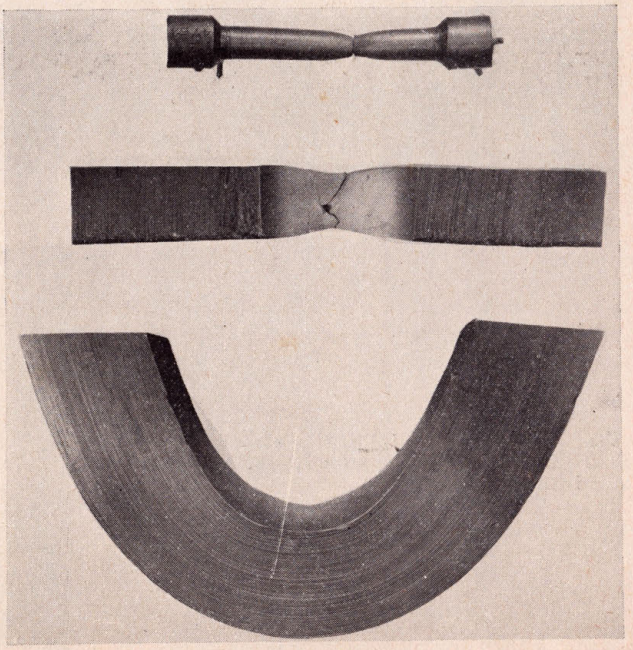

Fig. 10.—Physical test specimens after testing. Upper—all-weld metal tension; center—joint tension; lower—bend.

(Photographs on this page furnished by Metallugical Dept.)

off on the seams and numbered consecutively. The numbers are stamped on the drum for a permanent record. Each film bears two consecutive numbers, one at each end and as each picture overlaps those preceding and following, each number appears on two films, thereby assuring examination of the entire seam.

In addition to being a reliable indicator of the soundness of boiler drum welds for purposes of acceptance, radiographic examination is also used in connection with the development of welding procedures, the training and examination of welding operators and shop control of weld quality.

As a check on the radiographic technique, the Code requires that suitable thickness gages, called penetrameters, shall be employed to detect defects of a thickness equal to and greater than 2 per cent of the thickness of the base material.

The material of the penetrameter is required to be substantially the same as that of the plate under examination and the thickness must be not more than 2 per cent of the thickness of the plate. Three holes are required in each penetrameter, the diameters being, respectively, two, three and four times the penetrameter thickness, but in no case less than $^1/_{16}$ inch. The smallest hole and the identifying numbers must be distinguishable on the radiograph. Two sizes of penetrameters are required; one, $1^1/_2$ inches long and $^1/_2$ inch wide for plates up to and including $2^1/_2$ inches thick, and the other, $2^1/_4$ inches long and 1 inch wide for plates over $2^1/_2$ inches thick.

Two penetrameters are required for each exposure, one at each end of the exposed length on the side of the plate which is nearer the source of radiation. They must be parallel and adjacent to the weld seam with the small holes at the outer ends.

During exposure, the film is held as close as possible to the surface of the weld on the side farther from the source of radiation. When the film is not more than 1 inch from the surface of the weld, the Code specifies the minimum distances between the other weld surface and the source of radiation as follows:

Plate Thickness	Min. Dist. From Source of Radiation to Radiation Side of Weld
Up to 1 in.	14 in.
1 to 2 in.	21 in.
2 to 3 in.	28 in.
3 to 4 in.	36 in.
4 to 5 in.	38 in.

If it is necessary to expose the film at a distance greater than 1 inch from the weld, the Code requires the ratio:

$$\frac{\text{Distance from source of radiation to weld surface toward radiation}}{\text{Distance from weld surface toward radiation to film}}$$

to be at least 7 to 1 except that when a grid of the Buckey type is used to reduce scattered radiation, the ratio may be reduced to 5 to 1. The Code states that these conditions are imposed so as to obtain a practical maximum allowable distortion and magnification of any defects in the welded seam.

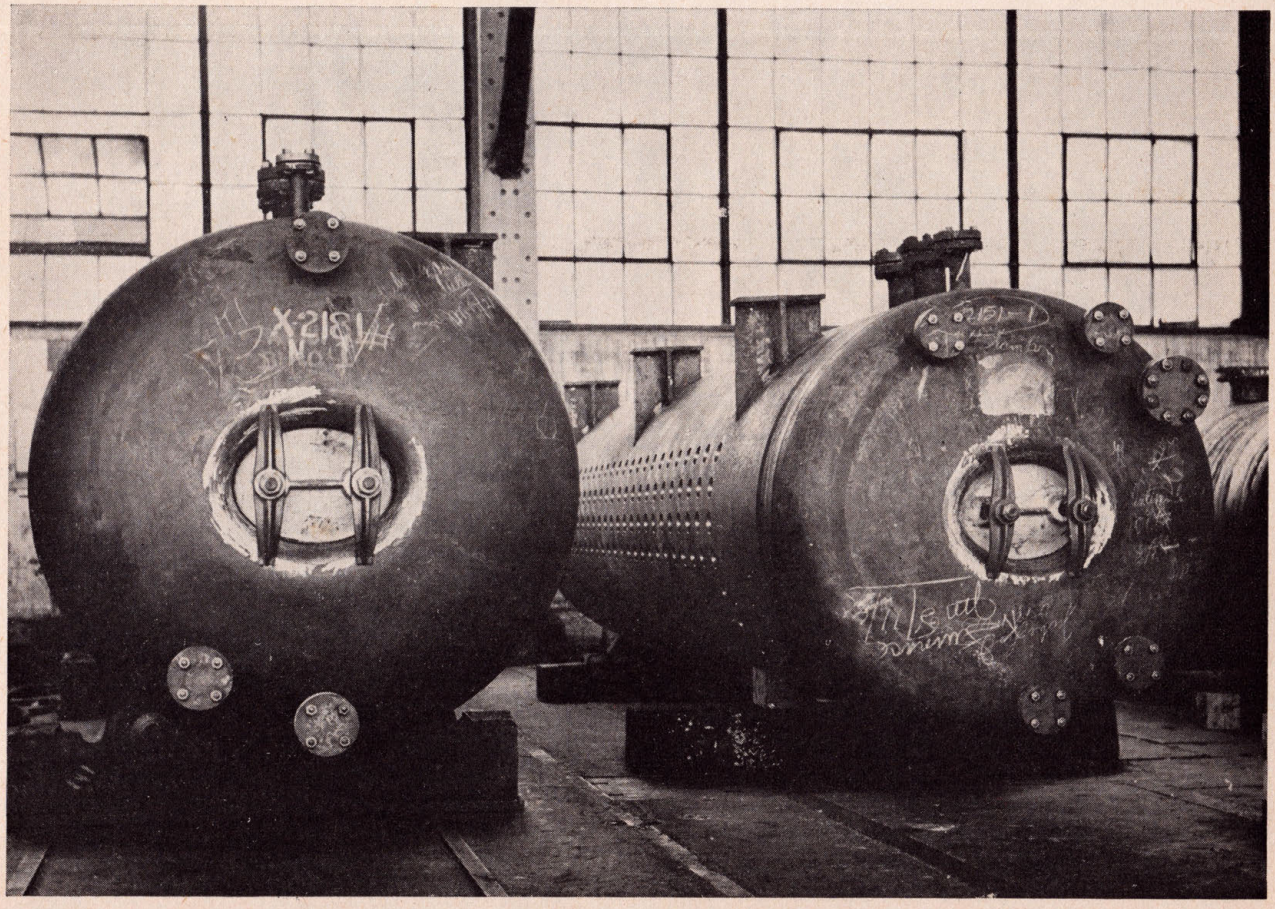

Fig. 11.—Completed drums ready for painting; superheater support brackets shown on right-hand drum

When the X-ray tube is operated at a voltage of 1000 kv or more and the Buckey grid is used on plates 3 in. or more in thickness, the foregoing specifications on technique may be modified in order to suit the particular requirements.

The acceptability of welds examined by radiography is judged by comparing the radiographs with a standard set of radiographs, reproductions of which may be obtained by purchase from the American Society of Mechanical Engineers.

Hydrostatic Test

4. After the stress-relieving operation, the welded drum is prepared for the hydrostatic test. Manhole plates are fitted, the pressure gage and feed line are connected and all remaining nozzles are blanked. The water used for testing is required to be not less than the temperature of the surrounding atmosphere and in no case less than 70 F. The rising pressure is kept under proper control so that the required test pressure is not exceeded by more than 6 per cent.

Drums are tested to either $1^1/_2$ or 2 times the maximum allowable working pressure (also known in the trade as "stamping pressure"), depending on the limitations of design stresses approved by the Code as of July 18, 1945. The hydrostatic test is witnessed by an insurance inspector, as specified.

Finishing

The drum is now ready for the finishing operations. If required, it is shot-blasted or sand-blasted, as specified, otherwise it goes directly from the hydrostatic test block to a face plate for tube hole layout. Here again, the shop inspectors carefully check the work that is being done.

The next operation is to drill and ream the tube holes, grooving them where required. A battery of radial drill presses is available for this work. Jigs are used during the drilling operation to assure accuracy in alignment. Then the drum is cleaned and tube holes are chamfered with revolving cleaners driven by air motors. At this point, there is an internal inspection by a representative of the insurance company, as specified. Drum internals are then installed and if required, drum chairs are fitted.

Final Inspection

The drum is now ready for inspection by an authorized C-E inspector and if desired, the customer may also make inspection. Upon approval by the inspectors, the tube holes are greased and capped and the drum is painted for protection during shipment and the subsequent handling.

After a final check by C-E inspectors, the drum is stamped near and above the manhole opening with the A.S.M.E. Code Symbol and identifying information such as the serial number and name of the manufacturer, year built, heating surface and maximum allowable pressure when built. The drum is then ready to be loaded for shipment to the customer's plant, where it will be erected as part of the assembly of a C-E boiler.

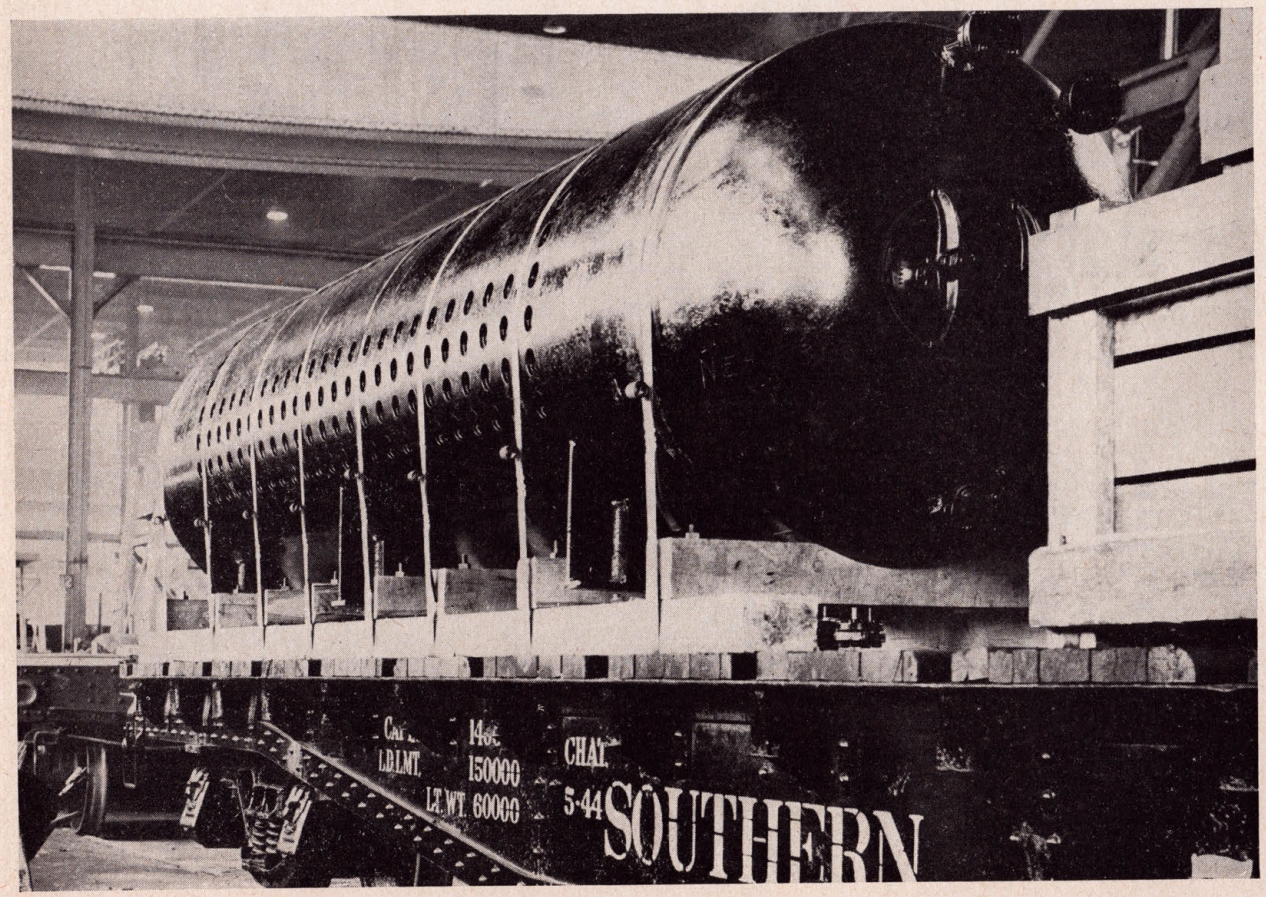

Fig. 12.—Completed boiler drum ready for shipment

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